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Seasonal Variations of Infiltration Rates of Forest Land Cover in Utisols Soils of Abini, Biase, Cross River State of Nigeria

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Abstract

This article provides insight into the seasonal variation of infiltration rates of utisol soils, under forest cover in Abini, Biase, Cross River State of Nigeria. The annual and seasonal amount of precipitation upon a place, and the soils capacity to absorb same, affects the degree and extent of the occurrence of ecological events, such as overland flow, runoff, erosion, flooding and landslide, quite inimical to land productivity. Thus the study investigated the response of forest soils to precipitation intake at different seasons, which is pertinent to landuse planning in both construction and agricultural industries. Data from the study were generated through field measurements of the infiltration rates of soils using a cylinder (flooding) inflitrometer designed by Hills [1] in two seasons of rainy (September-October) and dry (December-January) respectively, in rural watershed. The result showed seasonal changes in the equilibrium rates of infiltration form 9.6cm/hrt (rainy season) to 8.4 cm/hrt (dry season). This was indeed a hypothetical contrast from the expected ideal situation among infiltration experts, that infiltration values are supposed to soar in dry season than rainy season in the tropics. The factors of soil pore compaction and decline in the rates of biological activities accounted for this. Soil compaction reduces the rate of soil water loss through evaporation, enhances ground water conservation and stabilizes the soil structure for diverse benefits to man. Afforestation programme is hereby recommended to sustain the regional land ecosystem.

Keywords: Seasonal variation, Infiltration rates, Ecological events, Compaction of pores.

1. Introduction

The movement of water into the immediate soil surface either through precipitation, irrigation or other hydrological processes describes the phenomenon of infiltration. It involves three main components of surface entry, movement through the soil surface and reduction of soil storage capacity. The maximum rate at which the soil in any given condition is capable of absorbing water is called infiltration capacity, while infiltration rate on the other hand refers to the amount of water that passes into the ground surface at a given depth, per unit time [2]. Akintoye, et al. [3] have also examined the effects of land-use on the infiltration capacity of coastal plain soils of Calabar in Nigeria.

As an important process in the soil phase of the hydrologic cycle, infiltration determines the amount of run -off and supply of water into the soil profile [4]. Empirical works have proved the variations in infiltration rates of tropical soils resulting from high rainfall seasonality, parent material and the influence of vegetation. Studies by Antigha [5] showed marked variations in mean infiltration rates of soils under forested land cover of Akamkpa to be between 3.1 and 3.6 cm/hr-^{1} in dry and raining seasons of the year. In Ireland, Diamond [6] assessed the infiltration capacities of some extensive soils to determine their temporal and spatial variability. The result showed that the initial moisture content at 0.60mm depth was lower during summer than winter, with mean values of 0.38 mm and 0.70 mm. The mean steady infiltration rate (mm hr^{-1}) was given as 50.4 mm and 22.1 mm respectively. Also, studies by Ahn [7] in England revealed seasonal variations of mean infiltration rates to be 0.24 mm and 0.63 mm at summer and winter season to corroborates previous research findings.

From the above, an understanding of the moisture regime of soils of the study area depends on the estimate of soil water properties and control of the dynamics of water flow theory in time and space. Consequently, this paper provides information on water availability and moisture retention capacity of soils under forest land cover in Abini region at different seasons of the year, which is necessary for land use planning, both in the construction and agricultural industries, with implication for the manufacturing industries.

2. Study Area

The study area is Abini, in Biase, Cross River State of Nigeria. It is located between longitude $8^0$06 and $8^0$10'E and latitudes $5^0$00N and $5^0$38N. The area is characterized by humid tropical climate with distinct wet and dry seasons. Rainfall amount ranges from 3,500 mm to 4,000 mm per annum. The rainy season falls between April and October, with a short dry spell usually referred to as August break during the month of August [8].

It also has a relative humidity of between 80 and 90 per cent [9]. The temperature is moderately hot and does not fluctuate greatly with a mean range of 27^0C to 33^0C [10]. The geologic environment comprise of phyllites, schists with structural features as foliation, joints, fold intrusion, pegmatite and barite. The rocks are uncomfortably overlain by sedimentary sequence of calcareous sandstones with mineral contents of quartz, clay, calcite and fossils occurring as ridges [11]. The soils are mostly derived from cretaceous sediments of Eze Aku group [12] and are mostly lateritic in the upland area as essential residue products (deposits) formed under distinctive climatic conditions in tropical and subtropical regions. There are also calcareous soils containing quartz, calcite and fossils as dominant minerals. Being acted upon by human induced and natural processes, the soils occur in separate, but close ranges as silt loam, silt day, loamy, sand loam and clay loam, with varying textural characteristics of coarse gritty, powdery smooth to sticky and plastic feel.

The forest land cover is made up of woody and non-woody plants (parasitic, saprophytic and epiphytic climbers) which constitutes luxuriant and dense tree canopy, shading the soils from the vagaries of nature across seasons. This, in conjunction with other highlighted environmental variables influence the infiltration rates of regional soils at different scales, which can either be detrimental or beneficial to the local land resources.

3. Method of Study

A cylinder (flooding) infiltrometer designed by Hills [1] was used for field measurements in both rainy (September –October) and dry (December-January) seasons in rural watershed under forest land cover. A metal tube was driven into the ground to a depth of 10cm with a sledge hammer to avoid lateral flow of water during experiment. Care was taken to prevent damage to the soil structure in the process [13].

As a rule, a constant ponding level of 5cm was maintained in the metal tube (ring) throughout the experimental runs. Using a timer, readings were taken at various time interval, until a state of equilibrium, which is usually 180 minutes **was** reached. The experiment was replicated in rainy and dry seasons on the same land cover to determine seasonal variations in the infiltration capacity of the soils

Table-1. Equilibrium infiltration rate of forest land cover in rainy season (September-October)

Internal (Mins)	Cumulative time (mins)	Cumulative intake (cm)	Infiltration rates (cm/hr)
0	0	0	
5	5	1.6	12.0
5	10	2.0	11.8
5	15	2.5	10.2
5	20	4.0	12.0
5	25	4.5	11.0
5	30	5.5	11.0
10	40	7.2	11.0
10	50	8.8	11.0
10	60	10.6	11.0
15	75	11.6	10.0
15	90	14.8	9.6
30	120	18.6	9.6
30	150	24.4	9.6
30	180	28.8	9.6

Source: Authors fieldwork, 2012

Table-2. Equilibrium infiltration rate of forest landcover in dry season (December-January)

Internal (Mins)	Cumulative time (mins)	Cumulative intake (cm)	Infiltration rates (cm/hr)
0	0	0	
5	5	8.2	52.1
5	10	7.6	46.0
5	15	9.8	39.0
5	20	10.8	32.4
5	25	11.8	28.3
5	30	12.4	25.0
10	40	13.4	20.1
10	50	14.4	17.3
10	60	15.2	15.2
15	75	15.4	12.3
15	90	15.8	11.0
30	120	16.2	8.4
30	150	20.4	8.4
30	180	24.6	8.4

Source: Authors fieldwork, 2013

4. Result and Discussion

Table 1 and 2 show the equilibrium infiltration rate or the maximum water absorption rate of soils under forest cover at two different seasons of the year. It was discovered at the beginning of experiment in both seasons that soils exhibited strong capillary attraction (sorptivity) for moisture in the subsurface due to increased matrix potential (energy level) within particle surfaces. This gave the high values of infiltration recorded in the first 25-30 minutes. But as water percolated downward (transmissivity), the surface layers became semi saturated and capillary forces diminished **and** hence the reduction in infiltration rate values as time elapsed.

Most frequently, the values of (i) decline monotonically and tend to approach asymptotic state known as the final, equilibrium or steady state [4].

The study revealed a decline in the infiltration rate of experimental site from (9.6 cmhr) previously recorded in rainy season to 8.4 cmhr in the dry season. This was a sharp contrast from what obtains in other land uses in ideal situation where intake rate of soil is always higher in dry season, than observed. The factors of decline in soil biological activities and the compaction of soil pore accounted for the behaviour of the soil to its water absorption and transmission rate. This translate to mean that, in dry season, the rate of water loss to the atmosphere (evaporation) occasioned by high solar radiation is lower in forest soils than open or bare land surfaces. This finding is in line with [14, 15] that a good vegetation cover and surface condition greatly influence infiltration rate than soil type and texture.

5. Conclusion

The response of soil to water absorption according to seasonal variations is demonstrated in this study**.** Values of infiltration runs recorded in rainy and dry seasons in forest land cover revealed a hypothetical contrast from the popular notion among infiltration experts that the dry season readings must always rank higher in all soils under different land covers, especially in the tropics. The ability of forest soils to dynamically indicate a decline in soil biological activities leading to the compaction of pore spaces is nature's mechanism for reducing water loss to the atmosphere necessitated by litter decay and foliage protection. Hence, afforestation programmes should be encouraged as a measure of stabilizing the hydrologic cycle for the benefit of man.

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